TITLE: IMPROVED MODULE CLEANING METHOD

FIELD OF THE INVENTION

The present invention relates to membrane filtration systems, and more particularly to those systems employing porous or permeable membranes located in pressurised shell or, a tank or cell open to atmosphere and a backwash device therefor.

BACKGROUND ART

Any discussion of the prior art throughout the specification should in no way be considered as an admission that such prior art is widely known or forms part of common general knowledge in the field.

Porous membrane filtration systems require regular backwashing of the membranes to maintain filtration efficiency and flux while reducing transmembrane pressure (TMP) which rises as the membrane pores become clogged with impurities. Typically, during the backwash cycle the impurities are forced out of the membrane pores and/or scoured from the membrane surfaces into the feed tank or cell by one or more of pressurised gas, gas bubbles, liquid or a mixture thereof. The liquid containing impurities and deposits from the membranes is then drained or flushed from the tank.

Further, in filtration systems employing gas bubble scouring of the membranes it has been found advantageous to confine the bubbles as much as possible in the region of the membranes to assist with the scouring process.

Minimising the footprint of filtration systems is also desirable in terms of space eventually occupied by the filtration plant. Compact systems have lower cost, less waste volume, lesser impact on the environment and are more acceptable to the market.

It would be desirable to be able to provide the advantages of such systems to known systems which have been initially designed and manufactured without such cleaning and backwash processes in mind. Further it is desirable to simplify the manifolding and piping required to provide gas and liquid to the membrane modules during the filtration, backwashing and cleaning processes.

DISCLOSURE OF THE INVENTION

The present invention seeks to overcome one or more of the abovementioned problems of the prior art, provide one or more of the advantages outlined above or at least provide a useful alternative.

According to one aspect, the present invention provides an aeration/backwash device for use with a porous membrane filtration module including one or more membranes extending longitudinally between vertically spaced upper and lower headers into which the ends of the membranes are potted, the membranes having a permeable wall which, in use, is subjected to a filtration operation wherein feed containing contaminant matter is applied to one side of the membrane wall and filtrate is withdrawn from the other side of the membrane wall, the aeration/backwash device adapted to at least partially surround a portion of said membrane module and including a communication chamber having spaced through-openings in fluid communication with said chamber and the membrane module, wherein, in use, gas is supplied to the

chamber and communicated to the membrane module through said through-openings to aerate the membranes within the membrane module and liquid backwash is withdrawn from and/or fed into the membrane module through said through-openings into said chamber.

In one form, gas and liquid backwash may be selectively communicated through the same through-openings.

For preference, the through-openings are vertically spaced through-openings in fluid communication with said chamber and the membrane module, wherein, in use, gas is supplied to the chamber and communicated to the membrane module through at least the upper of said through-openings to aerate the membranes within the membrane module and liquid backwash is withdrawn from the membrane module through the lower of said through-openings into said chamber. It will be appreciated that liquid backwash may be withdrawn through both the upper and lower through-openings.

For preference, backwash or feed liquid may be fed or injected into the base of the module through the lower openings or both set of openings. These liquids may also be used to sweep solids along the membranes to carry out solids backwashed off the membrane surfaces during the gas scour. The backwash waste containing the solids can be flushed from the tank/cell by overflowing at the top of the tank/cell or by draining or pumping from the tank/cell through the through-openings.

Preferably, the vertically spaced through-openings include an upper and lower set of through-openings. For preference, the upper openings are smaller in cross-sectional area than the lower openings. Preferably, the openings of each set of through-openings are axially spaced around the periphery of the

chamber. In one form, the liquid backwash may be withdrawn from and/or fed through both sets of openings.

According to another aspect, the present invention provides a porous membrane filtration module including one or more membranes extending longitudinally between vertically spaced upper and lower headers into which the ends of the membranes are potted, the membranes having a permeable wall which, in use, is subjected to a filtration operation wherein feed containing contaminant matter is applied to one side of the membrane wall and filtrate is withdrawn from the other side of the membrane wall, the upper and lower headers being in fluid communication with one or both of the ends of said membranes and at least one associated upper and/or lower filtrate collection chamber such that, in use, filtrate withdrawn from said other side of the membrane wall is communicated through at least one of the upper and/or lower header to the associated upper and/or lower collection chambers, an aeration/backwash device at least partially surrounding a portion of said membrane module and including a communication chamber having spaced through-openings in fluid communication with said communication chamber and the membrane module, wherein, in use, gas is supplied to the communication chamber and communicated to the membrane module through said through-openings to aerate the membranes within the membrane module and liquid backwash is withdrawn from and/or fed into the membrane module through said through-openings into said communication chamber.

For preference, the through-openings are vertically spaced through-openings in fluid communication with said chamber and the membrane module, wherein, in use, gas is supplied to the chamber and communicated to the

membrane module through at least the upper of said through-openings to aerate the membranes within the membrane module and liquid backwash is withdrawn from and/or fed into the membrane module through the lower of said through-openings into said chamber.

Preferably, a filtrate connection pipe is provided in fluid communication between the upper and lower filtrate collection chambers and filtrate is withdrawn from one or the other of the collection chambers. For preference, the aeration/backwash device is located adjacent the lower header. Preferably, the upper and lower collection chambers include respective upper and lower collection cups adapted to detachably receive and engage in a fluid-tight manner said upper and lower headers. For preference, the headers are lockably engaged with the collection cups by means of a bayonet-type fitting.

According to yet another aspect the present invention provides a method of removing contaminant material from a feed liquid using a porous membrane filtration module according to the invention including the steps of

(a) performing a filtration operation wherein feed containing contaminant matter is applied to one side of the membrane wall and filtrate is withdrawn from the other side of the membrane wall,

(b) communicating said withdrawn filtrate through at least one of the upper and/or lower headers to at least one of the upper and/or lower collection chambers,

(c) supplying gas to the communication chamber and communicating said gas to the membrane module through said through-openings to aerate the membranes within the membrane module;

(d) backwashing said membrane wall using a liquid;

(e) withdrawing liquid backwash from the membrane module through said through-openings into said communication chamber.

Embodiments of the invention allow operation of a module in an inverted format, but also allow for gas and liquid scrubbing and sweep by the use of manifold arrangement installed near the base of the modules. The invention is described in relation to use with individual modules or arrays of modules in open feed tanks, however, it will be appreciated the invention can be equally be adapted to pressurised systems with the use of suitable pressure housings and connections. Desirably, the invention may be used with modules arranged to collect filtrate from both ends, but can equally be applied to modules with filtration from one end only. Filtrate can be withdrawn from the top or the bottom of the module.

In one embodiment, gas is supplied to an annulus surrounding the base of the module. The inside of the annulus contains through-openings that allow the gas to pass through and enter into the membranes. This embodiment also allows for additional openings positioned below the gas openings such that feed liquid may be fed into the base of the module and used to sweep solids along the membranes to carry out solids backwashed off the membrane surfaces during the gas scour. The backwash waste containing the solids can be flushed from the module by overflowing at the top of the tank/cell or by draining or pumping from the tank/cell and/or draining or pumping from the module through the openings.

The modules typically have a closed screen section in the middle that acts to contain the gas and backwash liquid so that it is more efficiently utilised. The

open areas allow gas and/or backwash waste to escape from the top and feed water or gas/backwash liquid to enter the module near the base.

The gas and backwash manifolds may be combined into one unit (as described above) or kept as separate manifolds.

Alternatively one set of openings only could be used with the openings being suitably shaped and sized, and spaced around the module such that gas only could be used first, then gas combined with liquid sweep for two phase scrubbing, following by liquid only sweeping. Suitable shapes include slots, triangular and tear drop shapes. Different combinations of these steps, with or without permeate back flush, may also be used.

In one embodiment, a solid section is provided in the screen which extends to just above the gas/backwash inlet openings at the bottom, and up to a short distance from the top of the module (typically, about 100mm). Alternatively, the screen can be solid along its full length but be provided with apertures adjacent the gas/backwash inlet openings and at the top of the module to allow flow of liquid and gas through the screen. During filtration, the module is submerged and feed liquid can enter the module through the open area at the top of the solid section and flow along the membranes. During backwash, aeration is carried out using the manifold arrangements and processes described above. The key advantage of this configuration is that when the backwash sweep occurs the backwash liquid sweeps along the membranes within the region surrounded by the solid section of the screen only, flowing out the top of the module and overflows from the tank or is drained away to waste. This process reduces the amount of backwash liquid required to accomplish the sweep compared to modules with a large open mesh screen (or no screen) as there is

no sweep flow outside the solid section of the screen, so that all the flow that is supplied to the module is used for sweeping. If necessary, any minor back mixing that might occur during overflow may be minimised by adding openings to the solid section near the base just above the aeration/backwash chamber such that a small and controlled amount of bypass occurs. The majority of flow would be directed through the module and the small bypass flow would gently flush any remaining solids or back mixed waste from the space between the modules so as to maintain essentially plug flow.

Alternatively, rather than perform the sweep step from bottom to top in the above arrangement, it is also possible to perform the sweep step from the top to the bottom utilising the backwash/gas line or some other waste connection at the base to carry the backwash waste away. In this case, the backwash may be caused to flow by gravity along the module by filling the feed tank to a predetermined height or maintaining the tank level above the module by the feed supply to the tank. In this case the volume of backwash waste will be similar to the situation above where the backwash feed liquid is supplied from the bottom with the significant advantage that no additional pump is required other than the existing pumps that supply feed to the tank or vessel.

Having the solid section of the screen or a shroud as part of the module also reduces the cost of constructing the device as it performs the multiple functions of protecting the fibres, providing the module support, and creating a vessel to contain liquid and gas during the backwash process. An external shell may also be used to provide the same function.

BRIEF DESCRIPTION OF DRAWINGS

A preferred embodiment of the invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Figure 1 shows a cross-sectional foreshortened schematic of a typical fibre membrane module having a backwash device according one embodiment of the invention;

Figure 2a shows side elevation view of the membrane module of one embodiment of the invention;

Figure 2b shows a sectional side elevation taken along A-A of Figure 2a;

Figure 2c shows an enlarged view of area C of Figure 2b;

Figure 2d shows an enlarged view of area B of Figure 2b;

Figure 3 shows an exploded part-sectional perspective view of the module of Figure 2a;

Figure 4 shows an upper perspective view of a module bank mounted located in a feed tank or vessel; and

Figure 5 shows a graph of transmembrane pressure (TMP) of a test module according to an embodiment of the invention over time.

DESCRIPTION OF PREFERRED EMBODIMENTS

Referring to Figure 1, the membrane module 5 comprises a plurality of porous hollow fibre membranes 6 formed into a bundle and extending between vertically spaced upper and lower headers 7 and 8 into which the ends of the fibre membranes 6 are potted. The upper and lower headers 7 and 8 are in fluid communication with the ends 9 of the fibre membranes 6 and associated upper and lower filtrate collection chambers 10 and 11 formed by upper filtration cap 12 and lower filtration collection cup 13. The fibre membranes are

supported between the upper and lower headers by a fluid impermeable screen 14 having apertures 3 and 4 just above the lower header 8 to just below the upper header 7, respectively. The apertures 3 and 4 at either end of the screen 14 are provided to allow for passage of gas and liquid to and from the module membranes 6. A filtrate pipe 15 extends through the centre of the membrane bundle and connects the upper and lower filtrate collection chambers 10 and 11.

An aeration/backwash device 16 as shown in Figures 1 to 3 surrounds a portion of the membrane module 5 above the lower header 8 and adjacent apertures 3 in the screen section 14. The aeration/backwash device includes a communication chamber 17 having vertically spaced upper and lower through-openings 18 and 19 in fluid communication with the communication chamber 17 and the membrane module 5. The communication chamber 17 is selectively connected via a pipe 20 to a source of gas or backwash liquid.

The upper and lower headers 7 and 8 include respective upper and lower potting sleeves 22 and 21 which sealingly engage by means of O-rings 23 and 24 with the upper cap 12 and the lower cup 13, respectively. The lower header 8 may be connected to the aeration/backwash device by any suitable detachable connection, in this case, a bayonet type connection 28 is used.

During operation, the modules 5 are submerged in a feed tank 25, suction is applied to the lower collection chamber 11 which in turn applies suction to the upper (via the filtrate pipe 15) and lower ends of the fibre membranes 6. Filtrate is collected in the filtrate cap 12 and cup 13 and piped away through manifold 26 (see Figure 2). The upper filtrate cap 12 and lower filtrate cup 13 of the module 5 are connected by the centre filtrate pipe 15 that collects filtrate from the upper filtrate cap 12 of the module and conveys it to the lower filtrate cup 13. This

connection between the upper and lower filtrate headers 7 and 8 may also be made by a connection outside the module 5, although in this embodiment it is shown here as being part of the module 5 itself. Filtrate may be collected from either end, but collecting from the bottom simplifies the manifolding. The filtrate collected is piped away through manifold 26 as shown in Figures 2 and 4.

Cleaning of the fibre membranes 6 is achieved during backwash by introducing gas, typically air, into the membrane module 5 through the upper of said through-openings 18 which act as aeration openings. These through-openings 18 are sized and spaced apart from the lower backwash through-openings 19 such that the majority of the gas passes through these openings 18 and maintains a liquid seal with the backwash openings19, although a small amount of leakage through the backwash openings 19 is tolerable. This ensures that the gas is distributed as evenly as possible around the module circumference. Once the gas scour using gas bubbles generated by gas fed into the module membranes 6 is complete (optionally combined with permeate back flush of the membranes), a liquid sweep is introduced via the backwash 19 and aeration openings 18. Any gas still in the chamber 17 is displaced though the aeration openings 18 initially and thus may be utilised in further gas scrubbing of the membranes 6. The chamber 17 then fills with feed liquid and flow occurs into the module 5 through both the aeration openings 18 and the backwash openings 19. The additional backwash openings 19 are provided to allow for a greater resistance of the liquid flow compared to that of the gas.

The liquid flow introduced into the base of the module 5 flows along the module 5 sweeping the solids from the module 5. The backwash waste can be

overflowed at the top of the vessel 25, drained away through outlets on the tank or vessel 25, or drained or pumped out of the openings 18, 19.

Additionally, the existing manifolding or an expanded manifold may be used such that as the liquid is introduced into the aeration/backwash device and chamber 17 it flushes gas from the chamber 17 carrying this into the module 5 thereby providing additional gas scrubbing of the membranes 6.

Gas may also be introduced into the chamber 17 or backwash line 20 at the same time as a back flush with feed is occurring. This allows for two phase scrubbing during the sweep stage, with the gas either separating in the chamber 17 or flowing through the aeration openings 18, or being carried with the backwash flow into the module 5 through any of the openings 18, 19.

Alternatively, one set of through-openings 18,19 only may be used with the through-openings suitably shaped and sized, and spaced around the module 5 such that gas only is used first, then gas combined with liquid for two phase scrubbing and sweep, followed by liquid only sweeping. Different combinations of these steps, with or without permeate back flush, may also be used.

Figure 4 shows how the modules 5 may be installed from above the tank 25 into filtrate and aeration/backwash manifolds 26 and 27 arranged along the bottom of the feed tank/vessel 25. The aeration/backwash manifolds 27 are connected to pipe 20 the aeration/backwash device 16.

Figure 5 shows a graph of transmembrane pressure (TMP) of a module according to the invention over time with drain down of the module contents

after each backwash. This graph shows that the TMP of the module according to the invention recovers effectively after each drain down.

It will be appreciated that further embodiments and exemplifications of the invention are possible without departing from the spirit or scope of the invention described.